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THESIS

DEVELOPING MULTIMEDIA INSTRUCTIONAL SYSTEMS: AN EXAMPLE APPLICATION FOR TRAINING IN NIGHT VISION GOGGLES

by

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iii

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TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

Modern air warfare has evolved both technically and operationally into a nighttime arena. Night vision goggles (NVGs) were developed to meet this need and their use has continued to increase. The goggles are able to amplify existing available light to better enhance a pilot's night vision. The skills necessary for optimal use of NVGs must be frequently practiced if personnel are to retain those skills (Gagne' and Briggs, 1979, p. 7). Training with these devices has been limited to traditional classroom instruction or on-the-job training. Thus, there is need for methods to augment current training for personnel who are unable to attend formal training programs.

Computer-based instruction (CBI), specifically multimedia applications, is a viable option to supplement and enhance current NVG training. Multimedia applications show great potential as instructional tools; therefore, the concept of designing and implementing an instructional multimedia application seems an appropriate step in improving flight operations with NVGs. As a training tool, it would allow pilots to maintain a high level of proficiency when on-the-job training is not available. This would result in greater mission success and improved overall safety when operating with NVGs.

This research paper builds on the work conducted by Bryant and Day (1994) who developed a multimedia prototype for NVG training. The primary goal of their research was to demonstrate the feasibility of using multimedia to enhance CBI. The goal of this paper is to research design principles appropriate for the development of interactive instructional systems using multimedia.

B. COMPUTER-BASED INSTRUCTION AND MULTIMEDIA

Computer-based training (CBT) can be used in various ways. It can be used for testing, management, instruction, simulators, and embedded training. The primary

emphasis of this paper is instruction and the terms CBI and CBT will be used interchangeably. CBT has many benefits. "In fact, adding computers to an already existing curriculum or media is one way of turning passive learning into active learning" (Kearsley, 1983, p. 1). Users can review difficult topics as many times as they desire and skip over topics well understood. CBI allows for each user to learn at a speed and manner suited to his or her style of learning. "It has been shown that instructional approaches based on passive presentation methods (i.e., classroom lectures, videotape) result in very little actual learning--on the order of a few minutes every hour....In interactive individualized instruction, the student spends a very high percentage of the time attending and, hence learning" (Kearsley, 1983, p. 10). Due to the interactive nature of CBT, students find it more motivating and experience greater learner satisfaction than other forms of instruction. Furthermore, the use of computers ensures that all students receive standardized instruction, although instruction may be delivered at different times and speed. (Kearsley, 1983, pp. 1-15).

"The capability of CBT to reduce training time is one of the most well documented and impressive outcomes" (Kearsley, 1983, p. 9). The time savings is about 30 percent and is almost completely due to the individualization of instruction. This can result in significant time savings because instruction can proceed at a faster rate. Traditional classroom instruction is structured around the slowest person in the class. Moreover, CBI solves the problem of providing instruction when and where it is needed. The user can choose the time and place to learn instead of being constrained by classrooms and schedules. Additionally, less resources are used due to the reduction in training. This can result in significant savings in terms of staff, facilities, and equipment. (Kearsley, 1983, pp. 5-12)

CBI can be accomplished using a variety of different types of instructional systems. In this paper, multimedia systems are the method chosen for providing instruction. "A multimedia computer system is one that is capable of the input and output of more than one medium" (Blattner and Dannenberg, 1992, p. xxiii). Input media typically refers to

2

devices, such as a keyboard or a mouse, used to interact with a computer. Output media consist of audio, video, animation, text, graphics, etc. The strength of multimedia systems is the ability to present information in a variety of different forms to aid learning and to motivate users to utilize the system (Kearsley, 1983, p. 15). The effectiveness of a multimedia system will depend on how well different types of media are used to present information. "It is now the communication with the user that is seen as the greatest obstacle to the efficient functioning of many systems" (Booth, 1989, p. 2). Thus, while multimedia systems have great potential for aiding learning, they must possess "inherent quality features that are achieved by thoughtful planning, sensitivity to user needs, careful attention to detail in design and development, and diligent testing" (Shneiderman, 1992, p. 7).

C. PURPOSE

The purpose of this thesis is to to implement a system for Night Vision Goggles (NVG) training based on design principles suitable for the development of instructional multimedia systems. The design principles must be based on instructional, multimedia, and system design theories and principles. In this paper, the subject of instructional design is closely examined. Cognitive learning theories and events of instruction relevant to the development of multimedia applications are presented. Multimedia design includes discussions of a developmental model for creating applications and media selection. System design is a summary of design guidelines, including a discussion on menu design. In summary, the development of instructional multimedia applications must be guided by sound design principles in order for intended users to readily absorb, process, and learn the material being presented.

A multimedia application was developed to demonstrate the use of the design principles learned. The development of the application involved making use of the acquired knowledge on instructional, multimedia, and system design. The purpose of the multimedia application is to provide instruction on the use of NVGs, and the numerous environmental and human factors that affect NVG night operations.

D. METHOD

The NVG multimedia application was jointly developed with Sean Epperson, another Naval Postgraduate School student. Although this research builds on the work of Bryant and Day (1994), the newly developed multimedia application was designed very differently from theirs. Their multimedia prototype focused on five main areas: (1) Night Vision Amplification Process, (2) NVG Terms and Glossary, (3) NVG Illumination Factors, (4) Parts of the NVG, and (5) Calibration Procedures. The new application divides the content into six main areas for greater granularity of instruction. They integrated audio, video, and text into the prototype. The use of video material is limited to lengthy video segments that are broader in scope and make it difficult to process and learn the information. Navigation through the prototype is accomplished using pushbuttons, in contrast to the use of a pull-down menu for new application. Overall, the prototype developed by Bryant and Day does a good job of demonstrating how multimedia, to include video and audio, can be used to enhance computer-based instruction. Moreover, Bryant and Day installed all the software and hardware needed to create a multimedia computer system.

On the other hand, what is lacking in their prototype is more domain knowledge about NVGs and the use of instructional and multimedia design principles. The new multimedia application created jointly with Epperson builds on their work by completely redesigning the menu format, screen layouts, expanding user interactivity, changing the presentation and adding greater NVG domain material, and properly using the different types of media, such as graphics and text, in an effort to complement the cognitive processes of a user and enhance his or her ability to learn. The application is described in greater detail in Chapter III.

Epperson was primarily responsible for providing animation sequences. He developed the displays for the topics of eye anatomy and NVG calibration procedures, and he, also, catalogued all video scenes. For example, he developed an animation sequence of the moon rotating through its four phases during a lunar cycle.

The development of the help utility, selecting the appropriate video scenes, designing the screen layouts, and developing the questions to include in the quizzes were jointly completed. For example, decisions were made jointly on the design and the colors to use for the main screen.

This author developed the framework for the application, designed the pull-down menu, and programmed the majority of the modules, except for those developed by Epperson as mentioned above. Additionally, this author designed the flow of information throughout the application.

The development of the multimedia application proceeded in a systematic manner. First, a literature review of available publications on instructional and multimedia design was conducted. This research guided the developmental process. The developmental process can be divided into three phases: preparation, planning, and production. The preparation phase consisted of learning the subject matter and collecting the source material needed, such as video, text, graphics, and audio, for incorporation into the application. Preparation, also, included obtaining and integrating the appropriate software and hardware needed to produce the application. Planning involve determining what content to include into the application, and how to present information to aid learning. The production phase was to program the application using authoring software.

E. ORGANIZATION OF PAPER

Chapter II examines instructional design, multimedia design, and system design principles applicable to the development of multimedia applications. Cognitive learning theories are presented that explain how people process and learn new information. Also, a developmental model for creating multimedia applications is discussed, and specific design guidelines are provided. Next, a description of the NVG multimedia application, including a discussion of the software and hardware utilized, follows in Chapter III. Finally, Chapter IV presents conclusions and recommendations for future multimedia research and development.

II. DESIGNING INTERACTIVE INSTRUCTIONAL SYSTEMS

Designing interactive instructional systems is a complex and time-consuming process that requires an understanding of how people learn, process new information, and interact with computers. Its primary objective is to enhance and facilitate learning by providing organization to content and presenting information in a manner that will provide appropriate forms of stimuli to a learner.

A. INSTRUCTIONAL DESIGN

Instructional design focuses on those processes that directly affect how people learn. Therefore, the emphasis of this chapter is to provide an overview of learning principles. Gagne' and Briggs (1979) define instruction as "a set of events which affect learners in such a way that learning is facilitated." This definition includes internal and external factors that facilitate or hinder learning. Internal factors refer to mental processes occurring in a person, whereas external factors are events and objects in our environment. (Gagne' and Briggs, 1979, p. 3)

1. Cognitive Learning Theory

Cognitive learning theory is concerned with mental models defined by cognitive science. Cognitive science can be viewed as "a collection of interwoven disciplines whose overall aim is to understand and explain the higher cognitive processes, such as understanding, thought and creativity" (Booth, 1989, p. 12). Cognitive science encompasses many disciplines, such as philosophy, psychology, linguistics, and artificial intelligence. The aim of studying cognitive processes is to understand what users understand and how they understand it. (Booth, 1989, p. 13)

Cognitive learning theory, as it relates to designing interactive instructional systems, requires a discussion of comprehension, attention, memory, active learning, and locus of control (Alessi & Trollip, 1991, pp. 11-13). Comprehension is concerned with how people perceive stimuli around them. New information is absorbed, classified, and

integrated with current knowledge. "We must not only store and retrieve information but be able to classify it, apply it, evaluate it, and manipulate it" (Alessi & Trollip, 1991, p. 12). Perception is an important cognitive process that facilitates learning because it allows us to receive and process information. Therefore, designers of instructional systems must develop courseware that heightens a user's perception if learning is to occur.

Attention can be "defined as a selective narrowing or focusing of consciousness and receptivity" (Filbert and Weatherspoon, 1993, p. 7). Filbert and Weatherspoon (1993, pp. 7-8) suggest that the novelty of multimedia is well suited for gaining, holding, and directing a user's attention. There are three strategies discussed for holding and directing learner attention: (1) advance organizers or presentation of learning objectives; (2) multiple media; and (3) high-attention devices. Advance organizers, such as video segments, are an ideal method of providing an overall lesson summary. Multiple media (audio, visual, etc.) provide variety during presentation and hold and direct a learner's attention. High-attention devices, such as animation or full-motion video, can be used to emphasize important concepts.

Memory can be divided into short-term memory (STM) and long-term memory (LTM). STM has limited capacity in terms of the number of items that can be stored (five plus or minus two) and duration (20 seconds or less). The capacity of STM can be increased by a process called "chunking." Chunking is the process of grouping or combining items into meaningful blocks of information. For example, rattlesnakes, lizards, gila monsters, coyotes, road runners, turtles, and scorpions could be thought of as a collection of animals found in the American deserts. (Filbert and Weatherspoon, 1993, pp. 9-10) Thus, to facilitate learning, multimedia applications must organize content into logical categories.

Information held in STM undergoes an important transformation, called encoding, before information is stored in long-term memory (LTM). When learner performance is required, the stored information is recalled from LTM into STM (working memory),

where it may be combined with incoming information to form new learned capabilities. (Gagne' and Briggs, 1979, p. 154) "LTM is a collection of organized knowledge, rules, procedures, and episodes" (Filbert and Weatherspoon, 1993, p. 10). LTM can be further divided into episodic and semantic memory. Personally experienced events are stored in episodic memory: whereas, semantic memory is a data base of facts and files with the ability to cross reference that information. (Filbert and Weatherspoon, 1993, pp. 10-11)

Gagne' and Briggs (1979, pp. 154-155) summarize the types of processing that are presupposed to occur during an act of learning as follows:

1. Attention determines the extent and nature of reception of incoming stimulation.

2. Selective perception transforms this stimulation into the form of object-features, for storage in short-term memory.

3. Rehearsal maintains and renews the items stored in short-term memory.

4. Semantic encoding is the process that prepares information for long-term storage.

5. Retrieval, including search, returns stored information to the working memory, to a response generator mechanism.

6. Response organization selects and organizes learned responses, or stored information.

7. Feedback is an external event that sets in motion the process of reinforcement, whereby stored information is compared with new incoming information to form new learned capabilities.

8. Executive control processes select and activate cognitive strategies; these modify any or all of the previously listed internal processes.

Active learning is the process of learning by doing. Instructional multimedia systems are well-suited for this task because they have the capacity to require and act upon user interaction. Interaction holds a user's attention and creates and stores new knowledge and skills. (Alessi and Trollip, 1991, p. 12) User interaction with the system can be further increased through practice, drills, and rehearsal. Moreover, practice and rehearsal reduce the amount of cognitive load a person incurs in carrying out a mental

task. This reduction in cognitive load is essential to learning complex cognitive skills. For example, a person learning how to speak a foreign language would first commit common words to memory before trying to construct proper sentences in that language. Thus, multimedia systems should emphasize user interactivity because people learn more efficiently by doing and practicing. (Filbert and Weatherspoon, 1993, p. 15)

Locus of control refers to whether control of sequence, content, methodology, and instructional factors are determined by the user or the computer. User control of applications enables a user to tailor instruction to his or her own pace and style of learning. For example, if the task is to remember a list of items, a user could control the rate at which information is displayed. Filbert and Weatherspoon (1993) suggest that user control provides additional motivation for a user and enhances semantic encoding of information for storage in long-term memory. User control is an ideal feature for adults because it makes them feel that they are in control instead of the system. Also, it is effective when the user is familiar with the material because the user is given the freedom to control the pace of instruction and the sequence of displays to suit his or her needs. The amount of user control should be determined by type of instructional learning system. A system that requires a user to perform specific procedures or demonstrate specific skills should have less user control than a system designed to provide exposure to a field of study. This is to ensure that a user achieves the target objectives of the system. (Filbert and Weatherspoon, et al., 1993, pp. 29-31)

2. Events of Instruction

Instructional events should be structured to parallel the learning processes previously discussed. Gagne' and Briggs (1979, p. 157) propose that there are nine sequential events of instruction that facilitate learning and enable a learner to achieve a target objective:

1. Gaining attention..
2. Informing the learner of the objective..
3. Stimulating recall of prerequisite learning.

10

4. Presenting the stimulus material.

5. Providing learning guidance.

6. Eliciting the performance

7. Providing feedback about performance correctness.

8. Assessing the performance.

9. Enhancing retention and transfer.

Gaining the learner's attention can be accomplished through stimulus change, such as animation. Fundamentally, instruction must appeal to the learner's interest through what is novel and capable of arousing curiosity. For example, a full-motion video clip may be used to illustrate how to make a complex adjustment to a piece of equipment. (Gagne' and Briggs, 1979, pp. 157-158)

It is important that a learner is informed of learning objectives for each lesson. The learning objectives are useful indicators that learning has been achieved. Additionally, learning objectives help a learner focus on what is important. Therefore, objectives must be concisely and clearly written in order to avoid any ambiguity. (Gagne' and Briggs, 1979, p. 158) The use of advance organizers, such as video segments, coupled with a statement of learning objectives is highly effective (Filbert and Weatherspoon, 1993, p. 23).

Stimulating recall of prerequisite learned capabilities may be crucial to learning. Previously learned capabilities are recalled to working memory and combined with new information received to achieve new learning. For example, learning Newton's Law of mass involves a combination of the concepts of acceleration and force, as well as multiplication. (Gagne' and Briggs, 1979, p. 159)

Stimulus material should be presented in a manner to emphasize the features of selective perception. Therefore, important information should be apparent. For example, information presented in text may be emphasized using highlighting, bold print, larger font size, or some other method to enhance perception of essential features. (Gagne' and Briggs, 1979, p. 160) There are many methods of presenting stimulus materials (visual,

audio, animation, etc.) that can be used. A designer of instructional systems must select the media that is best suited for stimulating learning and achieving the lesson objective. (Filbert and Weatherspoon, 1993, p. 23)

Providing learning guidance involves suggesting a line of thought, "hints," to a learner. These hints help to keep a learner focused on what is important, and help a person learn more efficiently. The amount of hints necessary for learning will vary according to the complexity of the material and the individual learner. Thus, hints should be given incrementally. A fast learner may require one hint, whereas a slower learner may require three or four. (Gagne' and Briggs, 1979, pp. 161-162) Interactive instruction systems are ideally suited for providing guidance to a learner and allowing the learner to make additional attempts to achieve a target objective because a person will not learn all that is taught the first time through.

Eliciting performance is fairly straight forward. A learner can be asked to answer questions or perform a specific action that will demonstrate that learning has occurred. Feedback can consist of informing learners of the correctness of their performance and clarifying misconceptions. Assessing a learner's performance can be accomplished by testing the learner's knowledge, which would demonstrate that the desired learning has occurred. (Filbert and Weatherspoon, 1993, p. 23) The goal is to activate retrieval of information and make reinforcement possible.

The final event of instruction, enhancing retention and transfer, aims to provide cues and strategies for retrieval of information. Retention and transfer can be enhanced by practicing the retrieval of skills acquired during an act of learning. (Gagne' and Briggs, 1979, p. 157) Moreover, a greater amount, type, and variety of interaction helps to insure that transfer of learning will occur. "In training situations, transfer is ultimately the most important instructional outcome" (Alessi and Trollip, 1991, p. 13).

B. MULTIMEDIA DESIGN

1. Design Methodology

In order to develop effective multimedia applications, a developer should follow a systems approach. Alessi's and Trollip's developmental model takes a systems approach; it is empirically based, driven by principles of cognitive psychology, emphasizes creativity, progresses from discussion to paper ideas to implementation on a computer, and it encourages a team-oriented approach. Empirically based means that development is iterative: draft, evaluate, and revise until the product functions as designed. The model advocates a team approach to development because more skills and knowledge are required than one person typically has, and a single developer is not good at criticizing his or her own ideas or work. (Alessi and Trollip, 1991, p. 246) Figure 1 lists all the steps of the model.

```
 1. Determine needs and goals
 2. Collect resources
 3. Learn the content
 4. Generate ideas
 5. Design Instruction
 6. Flowchart the lesson
 7. Storyboard displays
 8. Program the lesson
 9. Produce supporting materials
10. Evaluate and revise
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Figure 1: Developmental Model

The first step is to **determine needs and goals** for every lesson. This step involves writing specific learning outcomes (Howles and Pettengill, 1993, p. 59). For example, after the completion of a lesson, a learner should be able to describe the different phases of the moon and how moon elevation affects the level of ambient light available for night operations.

Collecting resources is the second step and one that should be thorough and exhaustive. A two-step approach is recommended. First, collect materials for learning the subject matter and resource materials on instructional design. Second, collect materials to be used in the multimedia presentation after designing the instruction sequence and concurrently with flowcharting or storyboarding the multimedia presentation. Make note of specific frame numbers of video material, list file names of clip art or graphical illustrations, and make a list of images to be created or digitized from hardcopies. Designers must be critical in selecting imageware. The selection of imageware will directly impact the learning process, and a multimedia presentation should be a highly visual experience. (Howles and Pettengill, 1993, pp. 59-60)

Learn the content before attempting to design instruction. This involves learning the subject matter from an expert or researching reference books on the subject. This step cannot be underemphasized. A thorough understanding of the subject is necessary for producing an effective instructional presentation. (Alessi and Trollip, 1991, p. 246)

Generating ideas can be accomplished by brainstorming. Do not spend too much time trying to come up with perfect ideas. Initially, designers should be as creative as possible and list as many ideas as possible without regard to their worthiness.

Design instruction. Brainstorming will generate good and bad ideas. It is at this step that bad ideas are eliminated, and good ideas are organized and refined. This is made possible by performing concept and task analysis on the content (Alessi and Trollip, 1991, p. 246). Selection of ideas should be guided by those that lend themselves to graphical or visual representation. Not every topic is suitable for inclusion into multimedia presentations; some topics are best presented by traditional classroom instruction.

Flowchart the lesson. "Flowcharting is important because computer-based instruction should be interactive, and interactions are best depicted as a visual representation of decisions and events" (Alessi and Trollip, 1991, pp. 246-247). Flowcharts, or structure charts, are important for determining the sequence of instruction.

The sequence of instruction should closely correspond to the needs and goals established for the multimedia presentation. If working as a team, the various members of the team should collaborate on flowcharting the sequence of instruction. If working alone, ask a colleague experienced in designing instructional multimedia presentations, or a colleague in your field to examine your work and give you feedback. The amount of work done beforehand will minimize the amount of time programming the presentation and costly revisions later in the developmental process. (Howles and Pettengill, 1993, p. 59)

Storyboard displays. While flowcharts describe the sequence of instruction, storyboards are used to depict the actual content, such as directions, pictorial displays, messages the user will see, prompts, audio, video, and text. The quality of the storyboards should be reviewed by all team members, potential students, and content experts, if available, and revised as required. This process helps to uncover ambiguities, confusing or missing content, and material that is too easy or too hard. (Alessi and Trollip, 1991, p. 247) The authoring tools available now make it possible to easily storyboard lesson content. The use of ordinary index cards are ideal for creating storyboards. The small size of the cards encourages designers to be thrifty in the amount of information placed on the screen at one time. Moreover, designers should not spend a lot of time trying to make a storyboard look neat since the goal of storyboarding is to provide a rough blueprint for the look and feel of the screen displays. (Howles and Pettengill, 1993, p. 60)

Program the lesson. This is the process of actually producing the multimedia presentation using the outputs from prior steps in the developmental model. Programming will proceed more smoothly if sufficient time and effort was spent upfront. Before starting, research the various authoring software programs available and pick one that best suits your needs. Utilize flowcharts and storyboards while programming. Take advantage of modules created for other applications. Use modular programming principles for efficiency. Document your application thoroughly. Ensure that the

program works before trying to make it more efficient. Do not strive for perfection the first time through. (Alessi and Trollip, 1991, p. 361)

Produce supporting materials. This consists of producing student manuals, instructor manuals, technical manuals, and adjunct instruction. Student manuals are necessary to help the user run the program and navigate through the application. Instructor manuals aid instructors in setting up a program, integrating a program into their course of instruction, and obtaining summary data on students, if appropriate. Technical manuals are required if setting up an application is complex, such as integrating a videodisc player, sound card, and video overlay card. (Alessi and Trollip, 1991, p. 247)

Evaluate and revise. The multimedia presentation and support materials should be evaluated by the designer(s) and other people with design experience. Evaluate the effectiveness of the presentation by assessing how much the users learn after completing the lessons.

2. Media Selection

Gagne' and Briggs (1979) propose two models for media selection: open and closed. In the open model, a senior designer makes the media selection. The designer chooses the medium that is best suited to present each type of instruction. He or she then assigns development work to persons with the proper media capabilities. This approach lends itself to smaller units of instruction that are more analytical and fine-grained. On the other hand, the closed model is more restrictive. A single medium, such as video, is chosen and designers proceed to select or develop that medium. The potential danger is that designers may tend to overuse a medium when some objectives could be better taught using other media. Moreover, the tendency is to use the medium for larger units of instruction. (Gagne' and Briggs, 1979, p. 179)

There are various factors relevant to media selection. The first of these factors is the type of task to be performed. For example, learning sign language can best be illustrated by a live demonstration, or a video, instead of using text. Additionally, the characteristics of learners should be considered when selecting media. Age of the

learners is a useful indicator when selecting media. Young children learn best by coming in "physical contact with objects, animals, and people, using all the senses to 'learn by doing" (Gagne' and Briggs, 1979, p. 181). As a person matures, new cognitive skills are developed to cope with more abstract stimuli. A person can then learn in a progressive manner. First, through demonstrations, then motion pictures, and finally by reading. It is suggested that media be selected to match a person's cognitive skills. Two final factors to consider are the development and learning environments. These factors have to do with the availability of media equipment, capability to produce imageware, expertise of designers, availability of content experts, and time and budget constraints. (Gagne' and Briggs, 1979, pp. 180-183)

Gagne' and Briggs (1979, pp. 185-193) provide a systematic method for media selection. The method begins with the lesson objective and ends with how the media will be produced in order to facilitate learning to achieve the lesson objective. Moreover, it emphasizes making media selections separately for each instructional event in a lesson in an analytical manner, which can be time consuming. Then a best choice is made, taking into consideration media for all events of the lesson, of what media to used. This detailed approach is an excellent learning aid for new designers because it forces designers to learn the developmental model and different instructional events. This method consists of the following ten steps:

1. Listing objective to be analyzed (learned) in a single lesson.
2. Classifying the objective in terms of the domain learning outcome, such as an intellectual skill or a motor skill.
3. Listing instructional events to be accomplished during lesson.
4. Selecting type of stimuli, such as audio or video.
5. Listing candidate media.
6. Selecting theoretically best media.
7. Making final media selections.
8. Establishing rationale for media choices.

17

9. Writing prescriptions for media production.

10. Writing script (media production).

Presentation of text on a computer has been taken for granted by designers of instructional multimedia applications. Text is an ideal medium for communication because it can express propositions about the past, present, and future conditions. Furthermore, text can form logical chains of cause and effect. It is also an ideal medium for providing messages to a user of the status of the system and explanations of commands and how to perform specific tasks. On the other hand, text is not as well suited for describing the physical properties of objects, illustrating numerical relationships, and for describing dynamic activities as other types of media. Additionally, text display needs to be prepared for the computer screen and not for a paper-based medium. Therefore, due to the limitations of screen size, designers should strive to be as concise as possible in their wording and capture a complete thought on a single screen. "The arrangement of information on a display determines not only how pleasing it is to the eye, but also comprehension, the speed at which it can be read, and the time needed to search for a key point...meaningfully segmented and identifiable text has been found to improve response times on reading tasks by as much as 16%." (Alber, 1993, pp. 263-267) Thus, text can be an ideal medium for communication if it is properly presented.

Users of multimedia systems have come to expect the use of graphics and pictorial-quality displays. Graphics can communicate information about the physical environment, improve the appearance of text on a screen, and can contribute visual relief and interest. Graphics need not be photographic quality. Research has shown that outline sketches, cartoons, and caricatures are more readily grasped than photographic-quality images. Relevant illustrations can aid in long-term retention of concepts and learning from text (Filbert and Weatherspoon, 1993, p. 75). There is, however, overhead involved in using graphic material. It is time consuming to develop if not available, can take up considerable computer disk space, and can slow computer response times. (Alber, 1993,

18

pp. 272-273) There are definite advantages to using graphics despite the overhead involved, if properly used.

Audio can complement almost any type of display. It is an excellent medium to explain complex ideas or reveal subtle points. Audio can increase appeal, redirect a user's attention to what is important, and can aid in recall of material. It should, however, be used in moderation in order to increase its effectiveness. Moreover, audio uses considerable amount of memory and more sophisticated hardware is needed to play audio files. Therefore, audio should be used to provide emphasis to important information and to add clarity to complex ideas. (Alber, 1993, pp. 275-276)

Video has tremendous visual impact and is ideally suited for multimedia systems; it captures and holds a user's attention. Video can be used to give an overview of a lesson, demonstrate how to perform a specific task, and can enhance learning because it can convey a large amount of visual information in a brief period of time. Thus, it is important to focus a user's attention to the video and not distract the user with other actions. The user should not be overwhelmed with long segments of video due to the limited capacity of STM. Short video segments followed by textual information are highly effective. Video, just like audio, is very memory intensive; computer response times can slow down considerably. (Alber, 1993, p. 254)

There is a trade-off between media selection and the amount of cognitive load demanded by each type of medium. Multimedia systems use a variety of media to present content to a user. It is difficult to compare which medium incurs greater cognitive demands on a user because each medium is processed differently (Benjamin and Spondre, 1993, p. 13). What is important is to recognize that combining different types of media can reinforce or interfere with the learning process.

The amount of cognitive load associated with text is dependent on the difficulty of the subject matter, a person's learning abilities, and the amount of domain knowledge a person possesses. Readers tend to absorb less information and stop to process, or reread, sections that are difficult, or unfamiliar, in order to better grasp their intended meaning.

19

Cognitive loading can be substantial if a person is a poor reader and/or unfamiliar with the subject matter. Conversely, persons with a vast domain of knowledge and proficient reading skills can process textual information in an efficient manner and incur less cognitive demands. (Benjamin and Spondre, 1993, pp. 16-18) In general, it is inappropriate to combine audio with text, except for very short messages, due to interference between the two media (Booth, 1989, pp. 30-34). The audio portion can adversely affect reading comprehension and retention. On the other hand, graphics, such as pictures or drawings, can increase understanding and enhance learning from text.

Pictures provide mental models that make learning new information easier. When combined with text, the text carrys the main message, but it is the picture that aids in mapping the information onto mental models, and subsequently into long-term memory (Benjamin and Spondre, 1993, p. 19). Graphics without text, or audio, can be confusing and are apt to be misinterpreted. The text, or audio, can be used to point out what information is important to extract from a graphic.

Full-motion video, which can include audio, text, and graphics, incurs substantial cognitive loading because different sensory stimuli are simultaneously received and processed. This information, however, is efficiently processed because people are conditioned to learn through sound, motion, and visual cues. These cues reinforce one another and enable people to process large amounts of information. Meaning can be conveyed independently by the audio or video, or both if synchronized (Benjamin and Spondre, 1993, pp. 14-22). Mixing passages of text and full-motion video would conflict with one another because of the overloading of the visual receptors and cognitive processors.

In summary, the goal of media selection is to minimize the interference in presentations and enable a user to efficiently process stimuli to allow for the transfer of as much information as possible from working memory into long-term memory. Each type of medium is processed differently, and the way it is presented makes a difference. Its presentation can enhance or hinder the learning the process. No single medium is

superior to all others. Each medium has its advantages and disadvantages. For example, a video clip can contain content, but not the objectives of the lesson. On the other hand, text lacks the power to explain and illustrate complex or abstract concepts in a brief manner. Learning is enhanced when different types of media are combined to provide different stimuli. In summary, the appeal of multimedia is its ability to present different stimuli simultaneously to a user in a manner to enhance learning and retention.

C. SYSTEM DESIGN

System design is concerned with sound design principles that are based on cognitive principles. For example, use of highlighting to emphasize the important points in text. Whereas instructional design focused on processes that affect how people learn, and multimedia design described a methodology for developing multimedia applications, system design focuses on practical and specific guidelines appropriate for the actual production of interactive instructional systems. Quality multimedia applications reflect these design principles and motivate people to use a system. Good design determines how information will be used and shapes users' perception of the system (Alber, 1993, p. 255).

1. General Design Principles

There is no single method for producing quality interactive instructional systems. There are numerous books on the subject. A compilation of design guidelines, which were deemed helpful and sound, from several textbooks are categorized and listed by the author in the appendix. These guidelines reflect the theories, principles, and methodologies described in the previous sections on instructional design and multimedia design.

First time designers of instructional multimedia applications should review and familiarize themselves with listed references and guidelines before attempting to develop multimedia presentations. Sound design principles should result in quality instructional presentations that will enhance learning and motivate people to use them. Poor design can

lead to confusion and frustration. For example, a display should not be presented to the user without any obvious manner of terminating the display and continuing with the presentation. On the other hand, a user may become bored by the presentation if response times are slow or navigating through the presentation is a laborious process. A user can react in different ways. A user can stop using the system, or use only a portion of it, or use it in a manner inconsistent with how a system was intended to be used. (Alber, 1993, p. 255) In summary, sound design principles will help to ensure that a presentation will enhance learning. Conversely, poor design can have a detrimental effect on learning and possibly discourage people from using instructional multimedia systems.

2. Menu Design

Well-designed menus are important because they determine how a user navigates through an application, and menus provide organization of content. Moreover, well-designed menus have the following benefits: (1) provide simple and unsophisticated access; (2) indicate the content of the system; (3) help the user search for particular information; (4) guide user logically through information; (5) facilitate classification and organization of content; (6) provide structure for planning and allocating types of information that will exist for each topic (Alber, 1993, pp. 260-261). The use of menus is also effective because they depend on user recognition of explicit menu choices rather than remembering and typing in line commands.

As applications grow larger, the number of menu choices will increase accordingly. This will require submenus and users may find it increasingly difficult to navigate through an application if not provided guidance. Menu maps are especially helpful for large menus. Shneiderman (1992) discusses studies that showed that users improved their performance when they were given a graphical menu map. (Shneiderman, 1992, pp. 113-115)

Menu-selection applications can be implemented using single menus, linear sequence menus, or strict tree structures. Single menus can take the form of binary menus, multiple-item menus and radio buttons, extended menus, pull-down and pop-up

menus, and multiple-selection menus or check boxes. The most common menu type for Windows programs seems to be the pull-down menu. This type of menu is extremely easy to use when using a pointing device such as a mouse. Linear sequence menus are used to guide users through several choices in which the same sequence of menus are displayed no matter what choices the users make. For example, printing dialog boxes that allow a user to select printing style, resolution, and number of pages. Tree structures are a way to categorize a large collection of items into mutually exclusive groups with unique identifiers. For example, animal, vegetable, and mineral can be a group. "Tree-structured menu systems have the power to make large collections of data available to novice or intermittent users. If each menu has eight items, then a menu tree with four levels has the capacity to lead an untrained user to the correct frame out of a collection of 4096 frames" (Shneiderman, 1992, p. 110). The selection of a particular type of menu will depend on the application structure and organization, and a designer's good judgement. Improvements can be made upon receipt of feedback and empirical data. (Shneiderman, 1992, pp. 100-116) Listed in Figure 2 are some guidelines for creating menus.

Illustrate the first two to three levels of menus and their interrelationships.
Make choices, clear, logical, and complete.
Avoid such generalizations as miscellaneous.
Balance conciseness and completeness.
Establish a hierarchy among frames.
Organize terms.
Provide consistency among frames.
Group information into logical categories.
Add descriptions and incorporate information where desirable.
Reveal size and scope of what is in each branch.
Insert statements directing user elsewhere or to curtail search.

Figure 2: Tips for creating menus. (Alber, 1993, p. 266)

III. NVG MULTIMEDIA APPLICATION OVERVIEW

A. DESIGN METHODOLOGY

The development of the NVG multimedia application was challenging and time-intensive. Development closely paralleled the model developed by Alessi and Trollip (1991), which was discussed in the previous chapter. The developmental process was iterative because at various steps work was evaluated and revised. This process of evaluation and revision continued throughout the developmental cycle. Additionally, the cognitive principles previously discussed influenced the development of the application.

The first step was to collect resource materials, such as books on night vision goggles, instructional design, multimedia design, and human-computer interaction. The next step was to learn the content. Domain knowledge was primarily acquired by reading the *Helicopter NVG Manual,* written by the Marine Aviation Weapons and Tactics Squadron One (MAWTS-1). Epperson and myself, attended a lecture, given by the coordinator of the Marine Corp's Night Vision Lab located in North Carolina, on NVG characteristics and operations.

The next step was to generate ideas on what to include in the prototype and how to best present information to the user. Epperson and myself generated ideas by conducting several brainstorming sessions. This was succeeded by the next phase of instructional design. The ideas derived from the brainstorming sessions were examined by Epperson and myself. An idea was deemed good if it was consistent with the principles of instructional and multimedia design discussed in the previous chapter. The good ideas were refined for use in multimedia and subsequently incorporated into the application.

Next, structure charts were created to organize the content. (See Figure 3 for an example of a structure chart.) This was followed by flowcharting the lessons using authoring software. The authoring software, Authorware Professional for Windows, made it possible to flowchart the sequence of instruction using a computer. Flowcharting was followed by the creation of storyboards. The storyboarding of displays was done

using Authorware, also. The Use of 3X5 index cards, as suggested by Howles and Pettengill (1993, p. 60), to design preliminary sketches of the storyboards was particularly useful.
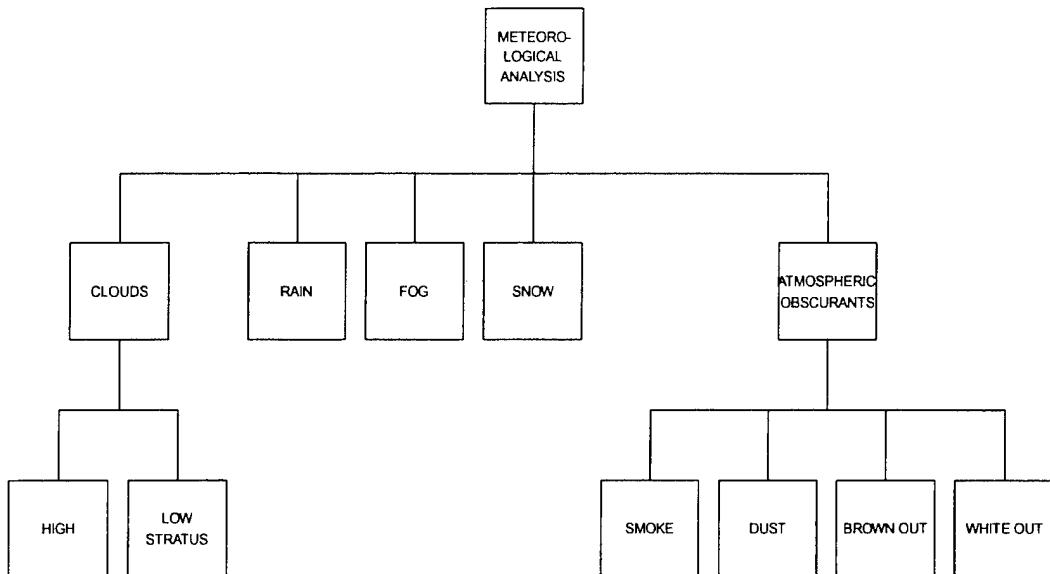
Figure 3: Structure Chart of Meteorological Analysis

Programming the multimedia application and integrating all source material into coherent modules was challenging and satisfying. All aspects of the application were influenced by one or more of the guidelines listed in the appendix. The programming was accomplished using Authorware. The amount of effort spent on the previous steps greatly impacted the time spent programming. The more preparation done on a particular lesson, the quicker it was to program that lesson.

B. APPLICATION OVERVIEW

1. Structure

The primary emphasis was on ease of use. Therefore, the application was given the look and feel of a typical menu-driven Windows application. The application content

was organized into logical categories: Human Factors, Goggles, Night Illumination, Terrain, Meteorological, EM (electromagnetic) Spectrum, and Help. The goal was to select terms that were concise and familiar to the user. Each category represents a lesson. Under each lesson, appropriate topics are listed. A user has completed a lesson when he or she has selected and completed all topics under that category. A quiz can be taken after completing each lesson. The purpose of a quiz is to provide feedback and reinforce the concepts learned.

2. Menu Design

A pull-down menu was used in order to make accessing menu options faster and familiar. Figure 4 is an illustration of the pull-down menu. A benefit of using this type of menu is that less memory is consumed because a single screen is used instead of having several screens with menu options represented by pushbuttons. Additionally, a mouse can be used to make menu selections, which is the best device for making a menu selection and rapidly moving to any spot on the screen. This gives the user the feel of directly manipulating the objects on the screen, which is important for user interaction. (Booth, 1989, pp. 25-28)

3. Screen Design

The aim in designing the screens was consistency. A subdued background was selected in order to increase contrast between the foreground and background. The number of colors was limited to less than five. The amount of information on a single display was limited to what was necessary to convey meaning to a user. As a result, all screens are lean and uncluttered. Textual information and images were positioned in the same locations for consistency. For example, pushbutton choices on submenu screens were consistently positioned in the same location.

4. Navigation

Navigation through the application is relatively straight forward. The main screen has a pull-down menu, which allows the user to terminate the application or make a

Night Vision Goggles Menu Map

File
| Quit |

Human Factors
| Eye Anatomy |
| Night Adaptation |
| Field of View |
| Visual Acuity |
| Types of Fatigue |
| Sleep |
| Circadian Rhythms |
| Effects of Fatigue |
| Quiz |

Goggles
| Components |
| Calibration |
| Operating Procedures |
| Quiz |

Night Illumination
| Introduction |
| Moon | => |
| Sources Other Than Moon | => |
| Light Level Planning Calendar |
| Quiz |

Terrain
| Reflectivity |
| Contrast | => |
| Shadowing |
| Quiz |

Meteorological
| Clouds |
| Rain |
| Fog |
| Snow |
| Sand/Dust |
| Obscurants |
| Quiz |

†
| Phases of Moon |
| Moon Angle |
| Moon Illumination |
| Return |

†
| Starlight |
| Airglow |
| Laser |
| Artificial Light |
| Return |

†
| Roads |
| Sand |
| Water |
| Foliage |
| Snow |
| Return |

Help
| Contents |
| About ... |

EM Spectrum
| Components |
| Illumination Levels |
| Quiz |

† These are screen submenus with pushbuttons.

Figure 4: NVG Menu Map

28

selection from the menu screen using a mouse. Subsequent screens allow the user to return to the main menu or continue with subsequent screens. The "Help" function is readily available at every screen if the user has a question of how the program works.

5. Video

Video was utilized to further amplify written text and provide an overview of material. The primary advantage of video is its visual impact that provides an abundance of information in a brief period of time. In this particular application, accessing video scenes is a slow process because video comes from a external source, a Hi-8mm VCR. The seek time for a particular video scene can take up to two minutes. Ideally, if the video scenes were stored on a laserdisc or CD ROM, access times would be minimal.

C. DESCRIPTION OF MODULES

1. Human Factors

This module includes two major topics, vision and fatigue. The vision topic includes instruction on eye anatomy, field of view, and visual acuity. The fatigue topic includes instruction on the types of fatigue, NVG missions, sleep, circadian rhythms, and the effects of fatigue. These two subtopics are separated by a line on the pull-down menu as shown in Figure 4. These human factors can greatly impact the effectiveness of NVGs and personnel safety.

2. Goggles

This lesson instructs the user on the different components of the NVGs and the adjustment procedures. The effectiveness of the NVGs is directly related to how well a person adjusts the NVGs to his or her physical characteristics. Improper adjustments can greatly degrade a person's visual acuity and cause a person to experience eye fatigue in a relatively short period of time. Properly adjusted NVGs can make the difference between a successful or a failed mission.

3. Night Illumination

To illustrate a typical menu selection, this section describes the screens displayed and the actions required by the user. This lesson discusses the natural and artificial sources of ambient illumination of the night sky. Natural sources include the moon, stars, and airglow. Artificial sources include city lights, lasers, and weapons. The menu choices available are "Introduction," "Moon," "Sources Other Than the Moon," "Light Level Planning Calendar," and "Quiz." Figure 5 shows two of the screens a user sees. Suppose a user selects "Moon." The succeeding screen summarizes the factors that affect moon illumination. The user presses the "Continue" button to proceed. The next screen is a submenu with the following choices represented by pushbuttons: "Phases of Moon," "Moon Angle," "Moon Illumination," and "Return." When any of the pushbuttons are selected, the pushbutton's color will change to inverse video, followed by an accompanying audible click, to let a user know that his or her choice is being acted on by the system. Selecting the "Phases of Moon" pushbutton will result in a video clip being shown, followed by a text screen highlighting the important points of the video clip just seen. The video screen has a "Continue" pushbutton to allow the user to terminate the video clip at any moment. The information screen that follows the video screen also has a "Continue" button to allow the user to return back to the "Moon" menu screen. The "Moon" menu screen, in turn, has a "Return" pushbutton that will return the user to the main pull-down menu screen. Upon returning to the main screen, the user can then make another selection or terminate the application.

4. Terrain

This module includes instruction on the topics of reflectivity, contrast, and shadowing. The different types of terrain reflect light in varying amounts. The terrain, therefore, determines the amount of light available for NVG operations. The amount of reflected light directly affects contrast levels and shadows. Contrast and shadows affect a person's ability to see terrain features and objects. Thus, personnel must be cognizant

Illumination From the Moon

Illuminance from the moon, at the earth's surface, is affected by the following factors:

1. Moon Phase

2. Variation in Earth-Moon Distance: During the lunar cycle, there is a total variation of about 26 percent in the distance between the earth and the moon.

3. Difference in Albedo on the Moon's Surface: The moon is about 20 percent brighter at first quarter than at third quarter due to differences in the lunar surface albedo (reflectance).

4. Moon Elevation

Continue
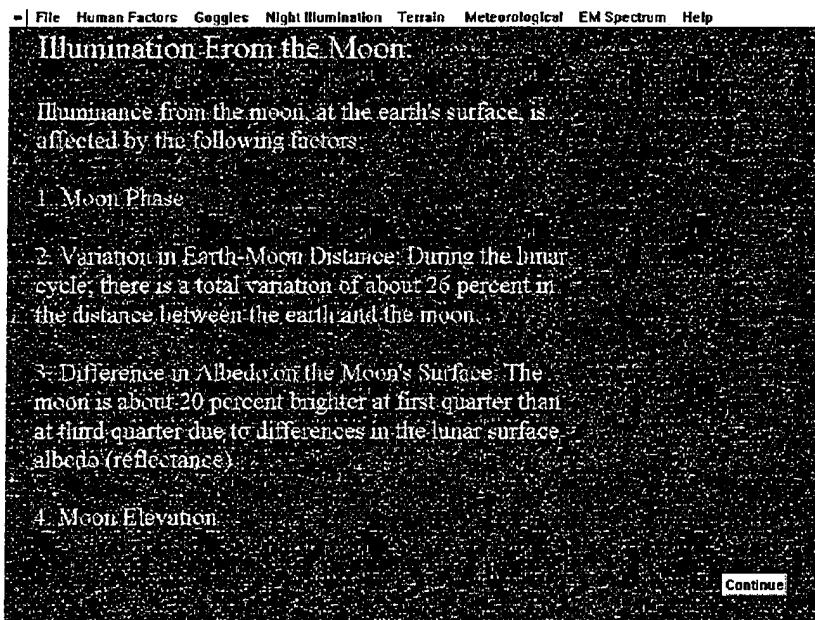
Illumination From the Moon
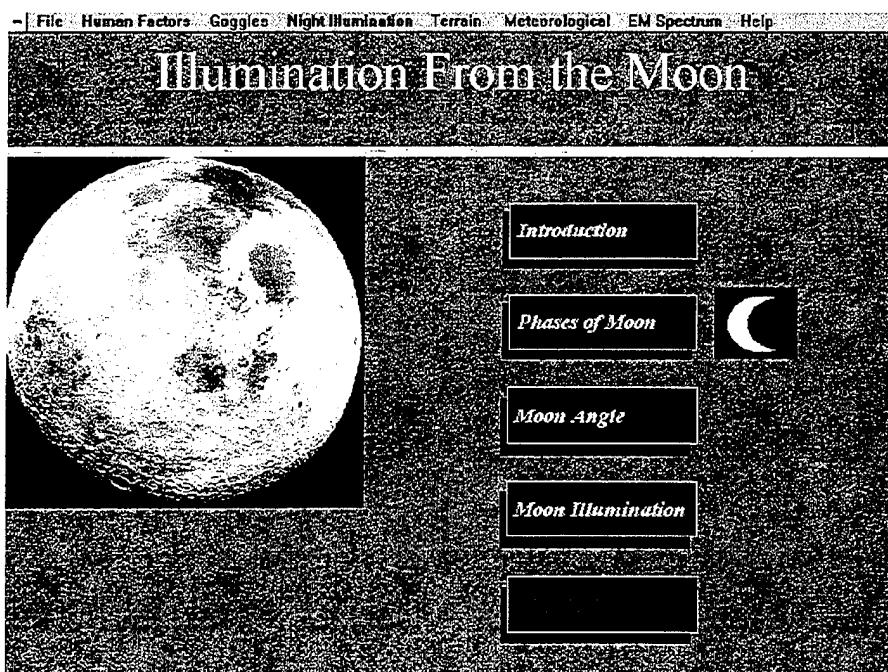
Introduction

Phases of Moon

Moon Angle

Moon Illumination
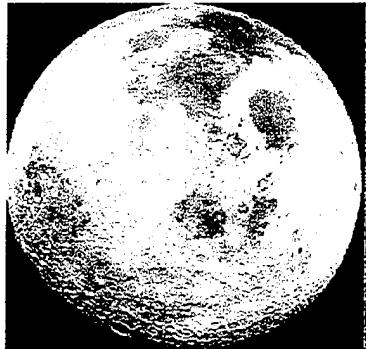
Figure 5: NVG Screen Displays

31

that what they will be able to see will depend on the type of terrain they will be operating in.

5. Meteorological

This lesson has instruction on the topics of clouds, rain, fog, snow, dust, and obscurants. These meteorological factors are discussed in terms of what impact they have on NVG operations. Each factor affects NVGs to varying degrees and personnel need to be aware of the impact on their visual acuity and situational awareness.

6. EM Spectrum

This modules teaches the user about EM spectrum and what the NVGs are capable of detecting in a night environment. The module includes instruction on what makes up the visible spectrum, the infrared spectrum, and the applicable portion of the light spectrum that NVGs operate in.

7. Help

This module includes a help utility and a screen about the application. The help utility includes a glossary section, a how to section, and brief module descriptions. The user can invoke the help function at any time. Furthermore, it is structured like other Windows applications for ease of use and familiarity.

D.   DESIGN TOOLS

1. Software

The most important software program for creating multimedia applications is an authoring program. The authoring program used to create the NVG multimedia application was Macromedia's Authorware Professional. Authorware Professional is a Windows-based authoring program that allows seamless integration of animation, audio, video, graphics, and text from a variety of sources. For example, video clips can be played from a laserdisc player or a VCR. Authorware is an object authoring program. Programming with Authorware is relatively straightforward. Icons are dragged to a

flowline and executed in the order placed on the flowline. Each icon represents an object that contains a set of instructions. Objects provide a way to graphically represent the logic of an application. Therefore, it is possible to flowchart an application without adding any functionality to the icons. (Macromedia, 1993) Another product from Macromedia, MacroModel, was used to create three-dimensional titles that had depth and texture.

Other software programs were essential for processing images before importing them into the application. Many of the images used in the application had to be converted from an incompatible file format to a format that was compatible with Authorware. Additionally, Video Director from Gold Disk, Inc., was extremely useful for cataloguing video clips. There is an abundance of software, such as animation software, that is available for creating source material for integration into a multimedia application. The software programs utilized in making the NVG application are listed below in Table 1.

	TYPE	MAKE	VERSION
1	Multimedia Authoring Tool	MacroMedia	Authorware Professional 2.01
2	Video Catologuing	Gold Disk, Inc.	Videodirector 1.0
3	Graphics Editor	Aldus	Photostyler 2.0
4	3-D Animator	Autodesk	3D Studio 3.0
5	3-D Graphics	MacroMedia	MacroModel 1.5

Table 1: Software

2. Hardware

The following computer components were instrumental in creating an effective multimedia application: video card, sound card, VCR, speakers, and a scanner. Truevision's Bravado card was used to accept video input from external sources, such as a VCR or a laserdisc. The strong point of the Bravado card is its capability to display

video at near full-screen. This is an important feature for viewing video scenes that have small details. Sony's Hi-8mm VCR was used to play 8mm tapes of NVG video scenes. The Pro Audio sound card, along with a good set of stereo speakers, is a must in order to play sound files. Finally, Hewlett Packard's full page scanner has the capability to scan and digitize, in color or black and white, any drawing, picture, or photograph. Thus, a scanner, preferably a full-page scanner, is an excellent tool to gather material for incorporation into a multimedia application. Table 2 is a listing of hardware utilized.

	TYPE	MAKE	MODEL
1	Personal Computer	ARM	486-DX2/66
2	Monitor	Phillips	2182DC (21 Inch)
3	Video Card	TRUEVISION	Bravado-16
4	Sound Card	Media Vision	Spectrum Pro-Audio
5	Color Scanner	Hewlett-Packard	HP Scanjet IIcx
6	Speakers	Sony	SRS-D2PC
7	Hi-8 Computer Video Deck	Sony	CVD-1000
8	VCR	Panasonic	AG-7350
9	Printer	Hewlett-Packard	HP Laserjet 4

Table 2: Hardware Setup

IV. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Instructional multimedia applications are promising advances in computer-based instruction. Learning can be enhanced and self-motivating. A user can modify the pace and the sequence of instruction to match his or her style of learning. Instruction can be done at the user's convenience, in contrast to traditional classroom instruction that is constrained by a schedule. Effective applications must, however, be based on learning theory, the correct use of media, and be created using a systems approach.

In order to create effective multimedia applications that facilitate learning, designers must integrate the principles of cognitive science into their presentations. A thorough knowledge of the internal mental processes that enable people to process new information, that is recombined with stored information, to learn new skills can be used to present material in multimedia applications in a manner that will support, and not interfere with, these internal processes. A developer must be cognizant of the events of instructions that occur during learning. Applications must support and reinforce these events.

Media selection can make the difference between an effective system or a one that is quickly abandoned. Each type of medium must be used according to its best use. For example, text is excellent for explaining numerical relationships, whereas video is an appropriate medium for illustrating physical objects. Furthermore, the combining of different types of media can enhance, or hinder, learning. The combination of text and pictures is highly effective because the two types of media reinforce each other. In contrast, the combination of text and video can be confusing and overwhelm a user due to increased cognitive demands and interference.

The development of any multimedia application should follow a systems approach. Alessi's and Trollip's (1991) developmental model encourages such an approach. A systematic method reduces the amount of time to develop an application and the final

product will be of much higher quality. Moreover, there are numerous books on multimedia and human-computer interaction. Specific design guidelines are extremely useful during the developmental cycle. These guidelines should influence every step of the developmental cycle and not only during the programming phase. The more preparation done in the early phases of development, the easier it will be to design and program an application. Thus, developers of multimedia applications must realize that a great deal of time will be required to develop an effective application.

There is a tremendous amount of time and labor required to create a multimedia application. This is especially true for first-time developers who must research instructional design, multimedia design, learn the content, and become proficient with the technology, software and hardware. Development of any application should not be undertaken as an individual assignment, but rather by a team of personnel with different skills. A team will undoubtedly possess many more skills than a single individual.

B.   RECOMMENDATIONS

The direction multimedia must take in the future is for greater integration of instructional principles. CBI should not be a linear process, but a dynamic and interactive process that brings into focus the cognitive abilities of a user and motivates that user to learn by using the system. A system must anticipate a user's actions and provide the proper amount of interaction. A system should, also, track a user's progress and adapt the instruction to address weak areas. CBI should make greater use of speech input and output for interaction between a user and a computer system. Moreover, the networking of computers would allow for greater sharing of resources and instruction to a greater number of users.

Future work on night vision goggles training should focus on obtaining source material on CD-ROM or laserdisc. If the proper equipment is acquired, the video scenes could be transferred from a video tape onto a CD-ROM. Also, evaluation of the effectiveness of computer-based instruction should be studied in a realistic training environment. It is important to ascertain what role CBI has in military training programs

36

and what portions of a curriculum are suited for CBI and which are best suited to be taught using more traditional methods. This research must be an on-going process to keep pace with changes in technology and advances in CBI principles.

APPENDIX. DESIGN GUIDELINES

There is no secret recipe for developing quality instructional multimedia presentations. A review of several references has resulted in a compilation of tentative guidelines than can be used. These are listed below:

(Filbert and Weatherspoon, 1993, pp. 72-76)

Cognitive

1. Attention is highly selective. We can give attention to only a small part of the environment at one time.

2. Attention is drawn to what is novel or different. By manipulating instructional displays the designer can readily introduce novelty.

3. Attention is drawn to moderate complexity.

4. Lean displays focus attention. Include only the most relevant information.

5. Learned cues can direct attention. Examples are arrows, underlining, circles, or rectangles around items. Another very effective cue is simply to direct the learner verbally to look for or listen to certain features. Captions can have a strong effect on the amount and kind of attention given pictures. Pictures without attention-directing prompts may be superficial and processed at a very shallow level.

6. Perception is organized. Learners try to construct meaningful wholes from their environment: objects, events, ideas. Unorganized stimulation is difficult to understand and remember. The designer who produces displays that are readily organized reduces the possibility that the learner will organize the material differently and perhaps erroneously.

7. Learning is highly dependent on prior knowledge.

8. Repetition increases learning.

9. Repetition with variety is superior to verbatim repetition.

10. Illustrations may function best in aiding long-term retention.

Color

1. Vision is most sensitive to colors in the middle of the spectrum, yellow and yellow-green, and least sensitive to those at the ends of the spectrum, violet/blue and red.

2. Learners prefer color. Especially when it has relevance and meaning ("red bird" may be associated with cardinal). Color can direct attention (e.g., highlighted word or section of a map).

3. Highlighting draws focus on salient points (italics, blinking, inverse video, color, etc.). Highlight sparingly: if everything is highlighted, then nothing is important.

Feedback

1. Providing feedback to learners after they have responded facilitates learning.

2. Feedback for incorrect responses should include corrective procedures and further testing and feedback as necessary.

Multimodal and Multimedia Interaction

1. Short lists are best presented in auditory form, longer ones in visual form.

2. Speech information should be used sparingly; expert summaries are better for learning than long passages if the auditory channel is used.

3. Simultaneous speech and visual presentation should be avoided, if the visual event or display must itself be interpreted in verbal form (verbal recording).

4. If a number of lists or facts are to be learned in a session, alternating the mode of presentation reduces forgetting due to interference.

5. Sounds (music and special effects) not relevant to the instructional theme can be distracting and should be avoided.

6. Use speech input to encourage vocalizing of material to be learned: this will enhance recall.

7. Where possible, keep the visual and auditory messages independent: do not assume these will always be presented together.

Navigation

1. Provide instructions. Put instructions on the screen.

2. Don't use timed pauses.

3. Remove inactive control options.

4. Always provide a way out.

5. Provide users with a sense of where they are in the lesson.

Screen Design

1. Leave lots of blank space. It prevents displays from getting crowded and important material can standout. Simpler is better.

2. Make important display items BIG.

3. Where possible, provide a consistent location for displaying new information (a particular region of the screen).

4. Displays or elements that appear close together in space or time tend to be grouped in perception and memory.

5. Displays and display elements that appear similar (size, shape, color, function, etc.) tend to be grouped in perception and associated in memory.

6. Concreteness in displays facilitates learning.

7. Build up displays incrementally. Don't flood the screen with all the information at once.

8. The amount of displayed information that can be processed at one time is quite limited.

Text

1. Break up long texts.

2. Connect text with graphics. Graphics can shorten lengthy textual explanations.

3. Learning from text will be aided by relevant illustrations.

4. Learning from text that students are required to read is not facilitated by unrelated illustrations.

5. Readers prefer illustrated text over nonillustrated text even when they do not extract information from the illustrations.

6. Where detailed prose is to be presented, it should be in the form of text that can be reviewed. Short summaries of this can be presented in auditory form.

7. Textual prompting or references to pictured information may aid the reader in extracting relevant information from complex illustrations.

(Booth, 1989, pp. 149-153)

Cognitive

1. Reduce the amount of information that the user has to remember; minimize the number of commands, objects, et cetera, that a user has to remember to perform a task, and if the user has to remember information for some time then the total number of items should not normally exceed five.

2. Try to arrange information that has to be remembered into meaningful chunks.

3. When it is anticipated that a significant number of older users (over 55 years) will have to use the system, then reduce the amount of information that has to be kept in mind.

4. Task sequences should be kept short, or broken down into sub-sequences.

5. A user should not be asked to perform two complex tasks together.

6. Make important information explicit.

7. If the user has to remember and then use information, do not fill the time between these tasks with irrelevant distracting information or activity.

8. Present information in the order in which it will be used.

9. Use familiar procedures when introducing new concepts so that existing bodies of knowledge can be used.

10. Use text materials to invoke relevant domains of user knowledge.

Content Organization

1. Keep the number of items subsumed under a single name or prompt as small as possible.

2. Generate categories and rules for categorizing items and provide information about the essential features of a category. Apply these rules consistently to items that the user should see as related.

Screen Design

1. Maintain logical and functional relationships between items on any given screen.

2. Give each type of information in a dialogue a consistent screen position.

3. There is more chance of the user remembering the last few items on a list, so place important information towards the bottom of any list.

4. When users need to progress rapidly through a series of transactions, use familiar labels or sequences of actions.

5. Provide powerful undo and redo keys.

Selecting Terms, Wording And Objects

1. When presenting instructions or feedback use affirmative sentences rather than negatives. Never use double negatives or nested negatives.

2. Construct sentences that are open to only one interpretation.

3. If essential information needs to be remembered, highlight it in an unusual way.

4. Do not use icons or pictures to represent abstract items or concepts.

5. Use simple, familiar concrete pictures to represent information and to act as memory prompts.

6. When it is important for users to remember and make associations with a visual pattern, keep that pattern simple.

Training and Practice

1. For systems incorporating novel concepts, provide on-line tutorials that provide (textual) information step by step.

2. Do not use text instruction as a short-cut to skill acquisition, practice is essential.

3. Training modes should protect users from the consequences of errors.

4. Make feedback positive not negative.

5. Consider combining the HELP function with some kind of computer-assisted learning that allows the user to try out different available courses of action.

6. Start gradually and encourage users to try out more complex facilities only as they gain experience, although this progression to more complex facilities must be under user control.

7. Avoid automatic interaction that deprives the learner of system control; where the consequences of inappropriate actions are serious, where the user needs to keep track of a long series of operations, or remember what happened in a given situation, or where sequences of actions have similar starting points, but different consequences.

(Alber, 1993, pp. 263-275)

Color

1. Use only enough colors to satisfy the needs of the application, generally five or less.

2. Colors of low inherent brightness make good background.

3. Colors of high inherent brightness make effective text presentations.

4. Complementary colors should be avoided.

5. Incorporate surprises using color.

6. Develop consistent color code.

Graphics and Pictorial Displays

1. Decide on reasons for incorporating imagery, such as to communicate information or aesthetic interest.

2. Follow principles of graphical excellence. Communicate ideas, clearly, precisely, and efficiently.

3. Give the viewer the greatest amount of information with the least number of bytes.

4. Minimize transmission delays and storage requirements. Maintain clip art in local memory, overlay drawing, and stage transmissions so that information is being buffered by the system while the user reviews information already received.

5. Use images in a sensible and careful manner. Avoid using the same images in multiple displays and be aware that detailed images can take a long time to display.

Text

1. Use uppercase and lowercase text for ease of reading.

2. Sentences should be short, simple, not threatening, and structured with important points at the beginning.

3. Use punctuation sparingly.

4. Complement text with simple line drawings.

5. Make each paragraph a meaningfully segmented block of text.

6. Locate labels and paragraph headings in the left margin.

7. Skip a row between paragraphs.

8. Start paragraphs on the left margin.

9. Use column formats for words and numbers likely to be sought and for sets of numbers.

10. Introduce displays logically (left to right, top to bottom).

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